The relationship between the distance from car-free zones and the value of housing prices

A case study on the city of Alkmaar, the most car-free city of the Netherlands

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Colophon

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Image title page In de Langestraat kun je over de koppen lopen by Rick Akkerman

Abstract

In this paper research has been done to analyse if car-free zones are off influence to the value of housing prices. According to previous studies, there is a relationship between the establishment of car-free zones and the rise in housing prices. These studies mostly looked at the before and after effects of implementing a car-free zone, as well as the differences between zones with and without car interference. However, no research has been conducted analysing the distance to a car-free zone on the value of housing prices. As a result, the aim of this study was to investigate this relationship. By performing a multiple linear regression using data on the city of Alkmaar this relationship became visible. The results showcased that there was a significant linear relationship between the dependent variable, being the log of the transaction prices and the independent variables transaction year, housing type, square metres living space, construction period and the distance from a car-free zone. The independent variables had a significant and high explanatory power of 79,3 percent. When looking specifically at the effect of distance to the car-free zone, this resulted in a significant standard coefficient of -0,066. Based on this value it can be stated that housing prices get reduced by 6,6% when moving 1 kilometre away from the car-free zone. In conclusion, it is clear that there is a significant negative linear relationship between the distance from the car-free zone and the value of housing prices.

Keywords: car-free zones, pedestrian zone, car prohibition, housing prices

Contents

1. Introduction

1.1 Background

Multiple factors have influence on the value of housing prices (Zietz, Zietz & Sirmans, 2008). These factors range from the location, type of neighbourhood, the property characteristics and the quality of the house and external factors like accessibility, safety, market situation and more. One factor that has influence on housing prices is, according to multiple academic articles, the implementation of a car-free zone in a certain area in a city (Cervero, et al. (2009); Arslanli, et al. (2017); Pollini (2019). Even though the side-effects are not completely clear and the discussion on if car traffic is essential in a city center has not been answered, an ongoing implementation is visible in the past years in many cities around the world (Sisson, 2020). A car-free zone is an area where the use of motorized vehicles like cars, trucks and motors, is prohibited (Topp & Pharoah, 1994). In the zone cycling, walking or public transport is the main way of getting around on the streets. Instead of using the streets as ways of enhancing mobility, they are now used to promote liveability (Cervero, et al., 2009). By implementing a car-free zone Topp & Pharoah (1994) stated that people using the area, experience a more pleasant stay because of multiple reasons. Positive influence from a car-free zone are for instance the reduction of noise and air pollution and the increase in safety and liveability which make these area's a more pleasant and attractable place to reside.

Multiple research has been done on the effect of the implementation of car-free zones on the value of housing prices. Cervero, et al. (2009) researched the implementation of surface boulevards, which are zones where cars are prohibited, and the effect is has on housing prices. They found that housing prices did increase due to the implementation of a car-free zone. This is backed by Arslanli, et al. (2017) who did research on the implementation of pedestrian only areas on land values. It was found that after implementing a pedestrian area, the area increased in liveability which increased the land values on these streets. Another study, done by Pollini (2019) researched the difference between neighbourhoods where car interventions where and where not implemented. This research resulted in that housing prices were higher in the area where the traffic intervention was applied because of a limited exposure to traffic.

1.2 Research problem

Despite these findings, no study has been done on the effect of distance to and from a car-free zone on the value of houses between neighbourhoods. Area's where car-free zones are implemented see an increase in liveability and safety and reduction in noise and air pollution (Soni & Soni, 2016). Therefore moving away from the car-free zone might result in a

decrease in the positive aspects and an increase in the negative aspects. This change in people's experience would therefore also change, which will be reflected in the value of housing prices. Investigating the effect of distance would therefore be of academic relevance and fill in the current research gap present with regards to this relationship. By analysing this relationship, this research will expand on the knowledge and existing literature present about the effect of car-free zones. Researching this relationship is also of societal relevancy to policy-makers whereby the positive and negative effects of the implementation to car-free zones on housing prices could be made clearer and therefore improve the decision-making process on these implementations. The aim of this research is to find out what effect the distance to car-free zones has on the value of housing prices across a city. This research will therefore try to answer the following research question:

"What is the effect of the distance to a car-free zone on the value of housing prices."

1.3 Thesis structure

In chapter 2 the theoretical framework of this article will be explained. The theoretical framework forms the basis of the analysis since aspects and variables who are of importance will be described in further detail. In Chapter 3 the data and methodology that is used to answer the research question is described. After doing the analysis the results are given in chapter 4. In chapter 5 the research question has been answered and concluding comments with regards to future research have been given. At last, in chapter 6, the research overall will be evaluated.

2. Theoretical framework

2.1 Car-free zone

A car-free zone is not an area where there are no cars allowed. Also, the concept has been interpreted differently among places and should be defined clearly. Topp and Pharoah (1994) described a car-free city area as an area-wide ban of car traffic to its functionally necessary share. They state that the zone is mainly implemented in order to enhance the liveability of a city centre by reducing the presence of parked and moving vehicles. Because of a reduction in car traffic in these area's it is encouraged to use other means of travel such as bikes and public transport. Public transport, like busses but also residents who live in the area and delivery trucks fall in the functionally necessary share of vehicles who are still allowed to make use of the zone. The article stated that car-free zones have positive effects on improving the quality of the particular area. People using these areas experience a more pleasant stay because of multiple reasons. Topp & Pharaoh (1994) state that this is the result of a decrease in noise pollution and increase in air quality. They also state that it is important that there is still a balance between different users like visitors, residents and economic activity like shops and bars.

An article by Soni & Soni (2016) state that because of the reduction or prohibition of cars in certain areas, benefits are gained for pedestrians. These benefits are grouped into transportation, social, environmental and health related gains. With regards to transportation, pedestrians experience an improvement in mobility and accessibility of the area which makes it safer and more enjoyable for its users. Social benefits of car-free zone are an increase in interaction, liveability, safety and security in the car-free zones. The environmental and health benefits which are gained for implementing a car-free zone is the reduction in air and noise pollution.

2.2 Effect car-free zone on housing prices

Cervero, et al. (2009) performed research on the deconstruction of roads in order to make room for surface boulevards in the city of San Francisco. In their article they noticed a shift in looking at urban areas where the focus was mainly on economic activity and thus a high priority on car-mobility in and out of the city. They state that these streets most of the time had negative influences like forming barriers between neighbourhoods, reduce visible quality of area's and have high noise, air and vibration pollutions. With an increase on car prohibition on certain roads in cities around the world, "priorities are now shifting toward promoting economic and environmental sustainability, liveability, and social equity" in cities. (Cervero,

et al. 2009, P. 32). The aim of the research is, among other things to find out what the transformation of roads to pedestrian friendly boulevards has for an impact on housing prices in that area. They performed their research by doing a hedonic regression on transaction prices in relation to housing and neighbourhood characteristics and the proximity to different transportation corridors before and after the transformation of the area. They found an increase in housing prices after the transformation of the area to boulevards.

Arslanli, et al. (2017) studied the effect of pedestrianisation on land values in the district of Beyoglu of the Istanbul metropolitan area. “Converting a street or an area for pedestrians only is called pedestrianization” (Lah, 2019, P.198). As a result, an area is transformed to a pedestrian only zone where automobile traffic is prohibited to a certain extend and thus forming a car-free zone. After the implementation of the pedestrian zone, as a way to revitalize the neighbourhood, an increase in land values was taught to be evident. The aim of the research was to find out if there was a relationship between the pedestrianisation of the area and the increase of land values and which underlying factors cause the potential increase. By doing a hedonic regression Arslanli, et al. (2017) found out that after the implementation of the pedestrian zone land values increased significantly. Factors resulting in this increase was the (re)opening of cinemas, theatres, stores, restaurants and an underground parking facility as well as the increase in alternative transportation facilities which was a direct consequence of an increase in the amount of pedestrians.

A study by Pollini (2019) researched the difference in housing prices between neighbourhoods who have and have no traffic reducing measures taken place. The aim of the introduction of these measures is to see if it increases liveability, which will be reflected in housing prices. It is stated that residential streets have a dual purpose of being thoroughfares for traffic as well as public areas where residents can reside and perform different kinds of activities. But as a result of an increase in population and thus in traffic these purposes come more and more in conflict with each other. By using a hedonic estimation method, the impact of traffic interventions is investigated between treated and untreated streets in the city of Portland. The analysis resulted in that the limited exposure to traffic due to the traffic intervention, has a significant increasing effect on housing prices compared to areas where there is no traffic intervention.

From existing literature it can be concluded that there is a relationship between car-free zones and the height of housing prices. However, this existing literature only looked at the before and after effect or the difference between treated and untreated neighbourhoods with regards

to the implementation of car-free zones. They did not look at the effect of living closer or further away from a car-free zone and what effect that has on housing prices. The aim of this research is therefore to find out if this relationship exists, if it positive or negative and how much explanatory power it has on the value of housing prices. The results will further expand on the knowledge and existing literature there is about the effect of car-free zones on housing prices.

2.3 Conceptual model

The conceptual model of this research is the visualisation of the relationship of the different variables in this analysis and has been visualised in figure 1. This model is based on existing literature with regards to the topic of car-free zones in relation to the value of housing prices. In the model it can be seen that "Distance from car-free zone" is the independent variable and "Housing prices" is the dependent variable. Based on the literature it is expected that the distance from a car-free zone has an effect on the value of housing prices which will be examined in this research.

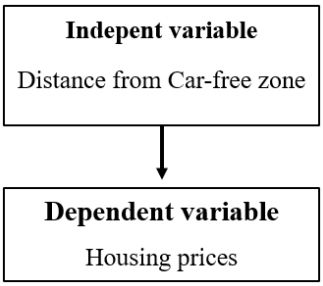


Figure 1. *Conceptual model*

3. Methodology

3.1 Multiple linear regression

The aim of this research is to find out if there is a relationship between the distance to a car-free zone and the value of housing prices. To find this relationship between the value of housing prices and the distance to a car-free zone, a multiple linear regression will be performed. A multiple linear regression will be applied in order to find a relationship between the value of housing prices and the distance to a car-free zone. A multiple linear regression is a quantitative approach which is capable of predicting housing prices based on multiple variables (Zhang, 2021). The multiple linear regression is a great fit for analysing the relationship between the dependent and the independent variable because it allows to control many factors, including nominal and ordinal variables, influencing housing prices. By controlling these different factors, the influence of the distance to a car-free zone could be analysed in an isolated setting and is therefore able to explain the possible explanatory power of the distance to a car-free zone on housing prices. Also, the multiple linear regression has been used thoroughly in existing literature with regards to this topic (Cervero, et al., 2009; Arslanli, et al., 2017; Pollini, 2019).

The distance to the car-free zone is the key dependent variable since it is the area of interest within this study. The height of housing prices is the independent variable which might be affected by the distance to the car-free zone. By adding control variables with regards to housing characteristics, the relationship between both variables could be analysed in a more isolated setting. In order to find out if there is a relationship between the different variables a null hypothesis is created. The following null hypothesis is used as basis of the regression:

"There is no relationship between the height of transaction prices and the distance from the car-free."

In order to state that there is a relationship between both variables and to answer the research question the multiple linear regression needs to be significant. When it is significant the null hypothesis can be rejected. After that it can be analysed if the relationship is strong or weak and has a positive or negative effect on the value of housing prices. It can also be analysed how much the dependent variable changes with an increase or decrease of 1 kilometre from the car-free zone.

A multiple linear regression has multiple requirements which need to be met in order to perform an appropriate analysis (Burt, et al., 2009). The first requirement is that the dependent variable needs to be ratio variable. Second, the data needs to be normally distributed. The third requirement is the absence of multicollinearity between the different variables. The last requirement is that the relationship between the independent and dependent variables is linear. Whether the collected data meets these requirements will be discussed in the following paragraphs.

3.2 Dataset

The data used in this study is derived from the Association of Dutch Real Estate Brokers called NVM. The Association of Dutch Real Estate Brokers is the largest brokers association in the Netherlands who gather data on transactions of properties around the Netherlands. This association consists of 4400 real estate brokers which gives them a market share of almost 40% in the Netherlands (Bolddata, z.d.). This dataset is used because it consists of transaction prices as well as characteristics of the different properties, which will be used as control variables. This makes this dataset a good fit for performing this analysis. In total 8011 transactions between 2005 and 2020 on all neighbourhoods of the city of Alkmaar have been gathered. The city of Alkmaar has been chosen as case study since it has one of the largest and centralised car-free zones of any city in the Netherlands. Despite that, Alkmaar is also an average city in the Netherlands with regards to its size and population.

3.3 Variables and descriptive statistics

The dependent variable is the transaction price of the properties. Transaction price is a ratio variable which is the first requirement for performing a multiple linear regression and is gathered on neighbourhood level. These transaction prices have a range from €70.000 to €1.400.000 as can be seen in table 1. The transaction prices are not the exact amount, but are instead the median of all the properties with certain characteristics. In total 8011 transactions are present in the dataset which are compiled in different groups based on their characteristics, which will be used as control variables. No outliers have been taken out since the highest transaction price will be controlled for by the different control variables. There are no transactions with a unrealistic low transaction price when looking at its characteristics. Because of a reasonable amount of high transaction prices and the variable ‘transaction price’ having an absolute zero, a high positive skew of 2,147 in the distribution is noticeable as can be seen in table 1 (Burt, et al., 2009). In order to meet the second requirement of a multiple linear regression this variable needs to be normally distributed. To prevent problems with

normality the dependent variable 'transactionprice_neighborhood_median' has been transformed into the natural log of this variable forming 'Log_transactionprice_neighborhood_median'. This improved the normality of the distribution as is visible in table 1. The third and fourth requirements of a multiple linear regression are the absence of multicollinearity and a linear relationship between the different variables. This requirement can only be checked after performing the regression and will therefore be discussed in chapter 4 'results'.

Table 1 *Descriptive statistics*

Variables	N	Mean	Std. Deviation	Minimum	Maximum	Skewness	Kurtosis
Transactionprice_ neighborhood_median	8011	269925,44	133204,178	70000	1400000	2,147	7,515
Log_transactionprice_ neighborhood_median	8011	12,4111	0,41880	11,16	14,15	0,566	0,233
Valid N (listwise)	8011						

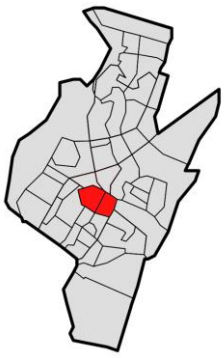
The independent variable in this study is the distance from the car-free zone. Because the data on transaction prices is only on neighbourhood level, this data is also gathered on neighbourhood level. The distance from the car-free zone is derived using a distance measuring tool from 'Ruimtelijke plannen'. The grey area in figure 2 is the area where cars are prohibited. As middle point of the car-free zone the 'Breedstraat' is selected, because this is the middle point of the zone in the city centre of Alkmaar. The car-free zone consists of 21 streets where the use of cars is prohibited for almost all vehicle traffic. Because there is only data about transaction prices on neighbourhood level, the centre of the neighbourhood has been selected as the reference point. From this point the distance is measured to the centre point of the car-free zone which is than processed into the dataset for that neighbourhood. This has been done for all the 50 neighbourhoods of the city of Alkmaar. A maximum distance of 5 kilometres is used in order to exclude the urban area of 'Graft-De Rijp' and also the rural areas around Alkmaar. Within these 5 kilometres all the urban neighbourhoods of the city of Alkmaar are included.

Figure 2 *Car-free zone of Alkmaar (Prettig Parkeren, z.d.)*

According to the zoning plan of the 'Gemeente Alkmaar' (Township of Alkmaar), the main car-free zone as visible in figure 2, has already been present since the determination of the zoningplan "Binnenstad Centrumgebied 2000" (Gemeente Alkmaar, 2012). Therefore, using transactions prices from after this period will give insight in the effect of car-free zones on the value of housing prices.

The different neighbourhoods are specified according to the Central Bureau of Statistics of the Netherlands, which the Dutch Association of Brokers used as bases in their dataset. The neighbourhood of 'Boekelermeer' has been cleared form the dataset since it did not have any housing transaction in the time period 2005 – 2020. A map of the different neighbourhoods has been visualised in figure 3. The red areas on the map are the neighbourhoods where the car-free zone is in located.

Figure 3 *Neighbourhoods of Alkmaar (CBS, z.d.)*



Transaction prices of houses are seen as the direct effect of different characteristics which increase or decrease the value of a certain property (Wittowsky, et al., 2020). In order to examine the relationship between distance to the car-free zone and transaction prices of houses in an isolated setting, control variables have been taken into account. When gathering data on the dependent variable, different control variables have also been gathered per case. For every case the transaction year, housing type, square metres living space and construction period is known.

Transaction year is the first control variable. This variable represents the year the transaction took place. This variable ranges from 2005 until 2020. Housing prices are sensitive to overall market fundamentals which differ over time (Liu & Shen, 2005). Housing prices have increased substantially between 2005 and 2020 with a period of economic downturn around the financial crisis of 2008 (Cadil, 2009). In order to control for these changes, the transaction year has been implemented as control variable per case. The second control variable is the housing type. The dataset distinguishes five different housing types, being: terraced house, corner house, semi-detached house, detached house and apartment. The third control variable is square metres of living space. Bigger houses have on average higher transaction prices than smaller dwellings (Olmo, 1995). These ordinal variables have been categorised into 13 different groups from ‘smaller than 80 square metres’ to ‘more than 600 square metres.’ The last control variable included into the dataset is construction period. As stated by Olmo (1995), the construction period has influence on the height of a transaction price. Therefore there is an overall positive relationship between construction period and transaction price. The control variable ranges from the year 1500 until 2020 and are grouped into different time periods.

Every control variable mentioned above is a nominal variable. In order to be able to perform the regression the control variables have been recoded into dummy variables. In order to make an comparison between the variables, a reference category needs to be selected for every control variable. For every variable the largest group is selected as reference category. This has been done because there is no normative category for every group, and therefore the largest group is expected to be the best fit. This means that for every group the following dummies have been selected as reference category:

- Transaction year: Dummy_2016;
- Housing type: Terraced_House;
- Square metres living space: Dummy_Between_80_100_M2;
- Construction period: Dummy_1970_1980.

4. Results

In this chapter the results of the multiple linear regression are given. The regression consists of the distance from the car-free zone per neighbourhood on the one hand and on the other hand the natural logarithm of transaction prices. Different control variables are made part of the regression in order to control for different characteristics between the transactions. The multiple regression has been performed in two blocks. The first block contains all the control variables. In the second block the distance to the car-free zone has been added in order to analyse if this variable increases the model.

When looking at the Anova table (see table 2) we notice that model one and two are both significant at the 5 percent confidence interval. This implies that we can reject the null hypothesis being *"There is no relationship between the height of transaction prices and the distance from the car-free."* Therefore, it is estimated that there is a linear relationship between the variables which is the 3rd requirement with regards to performing a multiple linear regression (Burt, et al., 2009).

Table 2 Anova table

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1081,357	39	27,727	683,071	,000[b]
	Residual	323,558	7971	0,041		
	Total	1404,915	8010			
2	Regression	1114,109	40	27,853	763,349	,000[c]
	Residual	290,806	7970	0,036		
	Total	1404,915	8010			

a. Dependent Variable: Log_Transactionprice_neighborhood_median

The model summary table visualises how well the models fits the data and is visualised in table 3. The multiple correlation coefficient, represented in column 'R', indicates the quality of the prediction of the independent variables on the dependent variable. With the models having a value of 0,887 and 0,891 of a maximum of 1, it can be stated that the prediction of the dependent variable is strong. The coefficient of determination, represented by the 'R square' and 'adjusted R square', is the percentage of the variance of the dependent variable that can be explained by the independent variables. With a height of 0,77 percent for model 1 and 0,793 percent for model 2, the independent variables explain respectively 77% and 79,3% of the variability of the dependent variable.

Table 3 Model Summary

Model Summary						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Sig. F Change
1	,877[a]	0,77	0,769	0,20147	0,77	0
2	,891[b]	0,793	0,792	0,19102	0,023	<,001

Table 4 is the last table of the multiple linear regression and contains the estimated model coefficients. Only model 2, which includes the variable "Kilometer_from_carfreezone", is presented in table 4. The full model has been put into appendix A as reference. The columns under unstandardized coefficients show how much the dependent variable changes when one extra independent variable is added and all other variables are held constant. When looking at the last row of table 4, where the distance from the car-free zone is located, it can be seen that it has a significance level of <0,001 making that the coefficient has significant explanatory power over the dependent variable. The last requirement for a multiple linear regression, being no problems with multicollinearity, can be derived from this table. When looking at the collinearity statistics it can be seen that this forms no problem since the tolerance is higher than the required 0,1 and VIF is lower than the required 10 for every variable (Burt, et al., 2009).

This than means that every requirement for performing a multiple linear regression has been met. Therefore the result of the multiple linear regression can be used to explain the relationship between the dependent and independent variable. This can be seen when looking at the unstandardized coefficient of the variable "kilometre from car-free zone" which is -0,066. Based on this result it can be stated that there is a negative relationship between the distance from a car-free zone and the value of housing prices. More specifically, this means that for every 1 kilometre a house is located further away from the car-free zone, the housing value drops by 6,6%.

Table 4 Outcome coefficients

Coefficients[a]							
Model		Unstandardized Coefficients		t	Sig.	Collinearity Statistics	
		B	Std. Error			Tolerance	VIF
2	(Constant)	12,2	0,011	1139,929	0		
	Dummy_2005	-0,116	0,011	-10,254	<,001	0,564	1,772
	Dummy_2006	-0,071	0,011	-6,237	<,001	0,567	1,764
	Dummy_2007	-0,024	0,011	-2,137	0,033	0,557	1,796
	Dummy_2008	-0,005	0,012	-0,443	0,658	0,597	1,676
	Dummy_2009	-0,062	0,013	-4,953	<,001	0,65	1,538
	Dummy_2010	-0,03	0,012	-2,505	0,012	0,619	1,615
	Dummy_2011	-0,048	0,013	-3,728	<,001	0,662	1,51
	Dummy_2012	-0,107	0,013	-8,496	<,001	0,651	1,536
	Dummy_2013	-0,154	0,012	-12,582	<,001	0,637	1,57
	Dummy_2014	-0,124	0,012	-10,699	<,001	0,594	1,684
	Dummy_2015	-0,091	0,011	-7,997	<,001	0,579	1,726
	Dummy_2017	0,123	0,011	11,285	<,001	0,541	1,849
	Dummy_2018	0,214	0,011	19,128	<,001	0,564	1,772
	Dummy_2019	0,291	0,011	26,003	<,001	0,564	1,774
	Dummy_2020	0,383	0,011	35,031	<,001	0,545	1,835
	Dummy_Corner_house	0,049	0,006	8,634	<,001	0,78	1,281
	Dummy_Semi_Detached_ House	0,185	0,008	22,397	<,001	0,818	1,222
	Dummy_Detached_House	0,334	0,009	35,517	<,001	0,774	1,293
	Dummy_Apartment	-0,034	0,007	-5,202	<,001	0,574	1,743
	Dummy_Smaller_80_M2	-0,207	0,008	-27,061	<,001	0,633	1,579
	Dummy_Between_100_120_M2	0,158	0,007	23,541	<,001	0,579	1,727
	Dummy_Between_120_140_M2	0,289	0,007	41,582	0	0,572	1,748
	Dummy_Between_140_160_M2.	0,415	0,009	48,412	0	0,679	1,472
	Dummy_Between_160_180_M2	0,579	0,011	52,854	0	0,753	1,328
	Dummy_Between_180_200_M2	0,666	0,014	48,69	0	0,83	1,205
	Dummy_Between_200_250_M2	0,788	0,014	54,918	0	0,82	1,219
	Dummy_Between_250_300_M2	0,963	0,024	39,644	0	0,93	1,075
	Dummy_Between_300_350_M2	1,147	0,041	27,679	<,001	0,968	1,033
	Dummy_Between_350_450_M2	1,085	0,047	23,118	<,001	0,976	1,024
	Dummy_Between_450_600_M2.	1,167	0,073	16,011	<,001	0,982	1,018
	Dummy_More_Than_600_M2	1,199	0,191	6,265	<,001	0,996	1,004
	Dummy_1906_1930	0,053	0,007	7,256	<,001	0,695	1,439
	Dummy_1931_1944	0,103	0,009	11,495	<,001	0,789	1,268
	Dummy_1945_1959	0,021	0,011	1,923	0,054	0,854	1,171
	Dummy_1960_1970	-0,049	0,008	-5,988	<,001	0,785	1,274
	Dummy_1981_1990	0,045	0,008	5,895	<,001	0,59	1,695
	Dummy_1991_2000	0,176	0,009	20	<,001	0,756	1,323
	Dummy_2001_2010	0,182	0,008	22,601	<,001	0,714	1,4
	Dummy_2011_2020	0,22	0,014	15,788	<,001	0,878	1,139
	Kilometer_from_carfreezone	-0,066	0,002	-29,96	<,001	0,615	1,627

a. Dependent variable: Log_Transactionprice_neighborhood_median

5. Discussion

The aim of this research is to find out what effect the distance from a car-free zone has on the value of housing prices across a city. The results showed that there is a significant relationship between these variables. Based on these results the research question being: *"What is the effect of the distance to a car-free zone on the value of housing prices."* can be answered. It can be stated that the effect of distance to a car-free zone has a significant negative effect on the value of housing prices. Specifically, with an increase of 1 kilometre from the car-free zone the value of a house drops with 6,6%. This means that the presence of a car-free zone has significant explanatory power on the value of housing prices. This relationship is in line with the findings of Cervero, et al. (2009), Arslanli, et al. (2017) and Pollini (2019), who al examined in one form or another the effect of some sort of traffic reduction/prohibition or pedestrian enhancing policy on the value of housing prices.

Cervero, et al. (2009) found in their study, on the effect of transforming roads to surface boulevards, that there is an increase in housing values visible after a car-free zone was implemented. Arslanli (2017) studied the relationship between pedestrianisation, which is converting streets to areas for pedestrians only' and what this has for an effect on land values. It was found that land values increase significantly after the implementation of a pedestrian zone in that area. Both of these studies show that prohibition or reduction of the presence of cars has an significant increasing effect on the value of housing prices in that area. These results are in line with the results gathered from the multiple linear regression which showed that there is a clear relationship between car-free zones and housing values.

But the results of this study probably align best with the findings of Pollini (2019). Pollini (2019) studied the relationship between traffic interventions and housing prices between treated and untreaded streets by also performing a hedonic estimation method. It was found that treated streets have significant higher housing prices compared to untreaded streets. This study aligns with the results derived from the multiple linear regression since the proximity to a car-free zone has a negative correlation on the value of housing prices.

6. Conclusion

In this research, the effect of distance to a car-free zone on the value of housing prices has been researched. Previous research has found a significant relationship between the implementation of car-free zones and the increase of housing prices. These studies mainly focussed on the before and after effect of the implementation of a car-free zone or the difference between zones where car prohibition was and was not included. However, no study has been conducted analysing the distance to a car-free zone on the value of housing prices. This study therefore aimed to analyse this relationship by trying to answer the following research question: *"What is the effect of the distance to a car-free zone on the value of housing prices."* By performing a multiple linear regression, using data on the city of Alkmaar, the research question has been answered. The data consisted of 8011 transactions in 50 neighbourhoods in the time period of 2005 until 2020 and included multiple control variables. The distance to the car-free zone in kilometres has been added to every transaction.

The results showcased that there was a linear relationship between the dependent variable, being the logarithm of the transaction prices and the multiple independent variables. The independent variables had a significant and high explanatory power of more than 79,3 percent. When looking at the distance to the car-free zone, this resulted in a significant standard coefficient of -0,066. This means that having a house 1 kilometre further away from the car-free zone, the housing value is being reduced by 6,6%. Because of this result it can be stated that the distance to a car-free zone has a negative linear relationship with the value of housing prices. The presence of a car-free zone has because of this a high explanatory power on the value of housing prices.

Despite the results this research comes with its limitations. One limitation of this research is that even though the dataset contained 8011 cases, there were different neighbourhoods which only had a couple of transaction in the period between 2005 and 2020. This made these dummy variables not significant and that they might have influenced the outcome of the regression negatively. Another possible limitation of this analysis is that for all the 8011 cases the distance to the car-free zone has been measured on neighbourhood level. This meant measuring the middle point of the car- free zone to the middle point of the neighbourhood. Because of weird shapes and different functions like industry and parks, this was not the most optimal measurement to use. The study could be improved when the distance to every individual case was measured. The dataset that has been gathered had multiple variables which could be used as control variables. However, more control variables like 'lot size' and

‘days the dwelling have been on the market’ could increase the explanatory power of the model and give more insight to the isolated relationships between these variables. Also, this research has only been performed on the city of Alkmaar. Alkmaar is an average city in the Netherlands which makes it analysis a good insight on other cities in the Netherlands. However, it would still be interesting to perform this analysis on multiple city’s inside and outside the Netherlands and see if the outcome of the relationship remains constant. By putting multiple cities in the database, the possibility to control for neighbourhood or municipality could further improve the model.

Future research could improve on the limitations previously mentioned on measurement levels, control variables, amount of cases and cities to give a more isolated and possible clearer insight in the relationship between car-free zones and housing prices. On top of this, future research could explore this relationship to other types of real estate like offices, shopping districts and hospitality which possible could be affected positively or negatively by the implementation of car-free zones. By doing this the relationship becomes clearer on a broader scale which will be of further interest to policy makers, planners and townships since it will help in the decision-making process of the implementation of car-free zones in cities.

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Appendix:

Appendix A: Model 1 and 2 of Multiple Linear Regression

Coefficients[a]

Model		Unstandardized Coefficients		t	Sig.	Collinearity Statistics	
		B	Std. Error			Tolerance	VIF
1	(Constant)	12,095	0,011	1134,607	0		
	Dummy_2005	-0,117	0,012	-9,854	<,001	0,564	1,772
	Dummy_2006	-0,072	0,012	-6,052	<,001	0,567	1,764
	Dummy_2007	-0,027	0,012	-2,277	0,023	0,557	1,796
	Dummy_2008	-0,011	0,012	-0,891	0,373	0,597	1,675
	Dummy_2009	-0,071	0,013	-5,385	<,001	0,651	1,537
	Dummy_2010	-0,04	0,013	-3,19	0,001	0,62	1,614
	Dummy_2011	-0,053	0,013	-3,934	<,001	0,662	1,51
	Dummy_2012	-0,116	0,013	-8,718	<,001	0,651	1,536
	Dummy_2013	-0,157	0,013	-12,106	<,001	0,637	1,57
	Dummy_2014	-0,125	0,012	-10,232	<,001	0,594	1,684
	Dummy_2015	-0,097	0,012	-8,053	<,001	0,579	1,726
	Dummy_2017	0,121	0,011	10,492	<,001	0,541	1,849
	Dummy_2018	0,212	0,012	17,994	<,001	0,564	1,772
	Dummy_2019	0,288	0,012	24,433	<,001	0,564	1,774
	Dummy_2020	0,383	0,012	33,195	<,001	0,545	1,835
	Dummy_Corner_house	0,042	0,006	6,969	<,001	0,782	1,279
	Dummy_Semi_Detached_House	0,162	0,009	18,64	<,001	0,826	1,211
	Dummy_Detached_House	0,29	0,01	29,611	<,001	0,793	1,261
	Dummy_Apartment	0,006	0,007	0,814	0,415	0,598	1,672
	Dummy_Smaller_80_M2	-0,203	0,008	-25,19	<,001	0,633	1,579
	Dummy_Between_100_120_M2	0,15	0,007	21,23	<,001	0,58	1,724
	Dummy_Between_120_140_M2	0,282	0,007	38,456	<,001	0,573	1,746
	Dummy_Between_140_160_M2.	0,416	0,009	46,033	0	0,679	1,472
	Dummy_Between_160_180_M2	0,587	0,012	50,794	0	0,753	1,328
	Dummy_Between_180_200_M2	0,673	0,014	46,602	0	0,83	1,205
	Dummy_Between_200_250_M2	0,812	0,015	53,672	0	0,823	1,216
	Dummy_Between_250_300_M2	1,015	0,026	39,691	0	0,935	1,069
	Dummy_Between_300_350_M2	1,197	0,044	27,406	<,001	0,969	1,032
	Dummy_Between_350_450_M2	1,141	0,049	23,057	<,001	0,978	1,023
	Dummy_Between_450_600_M2.	1,226	0,077	15,961	<,001	0,983	1,017
	Dummy_More_Than_600_M2	1,31	0,202	6,491	<,001	0,996	1,004
	Dummy_1906_1930	0,102	0,008	13,47	<,001	0,731	1,369
	Dummy_1931_1944	0,146	0,009	15,683	<,001	0,81	1,235
	Dummy_1945_1959	0,056	0,011	4,97	<,001	0,865	1,156
	Dummy_1960_1970	-0,048	0,009	-5,577	<,001	0,785	1,274
	Dummy_1981_1990	-0,049	0,007	-6,772	<,001	0,712	1,405
	Dummy_1991_2000	0,138	0,009	15,06	<,001	0,772	1,296
	Dummy_2001_2010	0,161	0,008	18,971	<,001	0,72	1,389
	Dummy_2011_2020	0,236	0,015	16,114	<,001	0,88	1,137
2	(Constant)	12,2	0,011	1139,929	0		
	Dummy_2005	-0,116	0,011	-10,254	<,001	0,564	1,772
	Dummy_2006	-0,071	0,011	-6,237	<,001	0,567	1,764
	Dummy_2007	-0,024	0,011	-2,137	0,033	0,557	1,796
	Dummy_2008	-0,005	0,012	-0,443	0,658	0,597	1,676
	Dummy_2009	-0,062	0,013	-4,953	<,001	0,65	1,538
	Dummy_2010	-0,03	0,012	-2,505	0,012	0,619	1,615
	Dummy_2011	-0,048	0,013	-3,728	<,001	0,662	1,51
	Dummy_2012	-0,107	0,013	-8,496	<,001	0,651	1,536
	Dummy_2013	-0,154	0,012	-12,582	<,001	0,637	1,57
	Dummy_2014	-0,124	0,012	-10,699	<,001	0,594	1,684
	Dummy_2015	-0,091	0,011	-7,997	<,001	0,579	1,726
	Dummy_2017	0,123	0,011	11,285	<,001	0,541	1,849
	Dummy_2018	0,214	0,011	19,128	<,001	0,564	1,772
	Dummy_2019	0,291	0,011	26,003	<,001	0,564	1,774

Dummy_2020	0,383	0,011	35,031	<,001	0,545	1,835
Dummy_Corner_house	0,049	0,006	8,634	<,001	0,78	1,281
Dummy_Semi_Detached_House	0,185	0,008	22,397	<,001	0,818	1,222
Dummy_Detached_House	0,334	0,009	35,517	<,001	0,774	1,293
Dummy_Apartment	-0,034	0,007	-5,202	<,001	0,574	1,743
Dummy_Smaller_80_M2	-0,207	0,008	-27,061	<,001	0,633	1,579
Dummy_Between_100_120_M2	0,158	0,007	23,541	<,001	0,579	1,727
Dummy_Between_120_140_M2	0,289	0,007	41,582	0	0,572	1,748
Dummy_Between_140_160_M2.	0,415	0,009	48,412	0	0,679	1,472
Dummy_Between_160_180_M2	0,579	0,011	52,854	0	0,753	1,328
Dummy_Between_180_200_M2	0,666	0,014	48,69	0	0,83	1,205
Dummy_Between_200_250_M2	0,788	0,014	54,918	0	0,82	1,219
Dummy_Between_250_300_M2	0,963	0,024	39,644	0	0,93	1,075
Dummy_Between_300_350_M2	1,147	0,041	27,679	<,001	0,968	1,033
Dummy_Between_350_450_M2	1,085	0,047	23,118	<,001	0,976	1,024
Dummy_Between_450_600_M2.	1,167	0,073	16,011	<,001	0,982	1,018
Dummy_More_Than_600_M2	1,199	0,191	6,265	<,001	0,996	1,004
Dummy_1906_1930	0,053	0,007	7,256	<,001	0,695	1,439
Dummy_1931_1944	0,103	0,009	11,495	<,001	0,789	1,268
Dummy_1945_1959	0,021	0,011	1,923	0,054	0,854	1,171
Dummy_1960_1970	-0,049	0,008	-5,988	<,001	0,785	1,274
Dummy_1981_1990	0,045	0,008	5,895	<,001	0,59	1,695
Dummy_1991_2000	0,176	0,009	20	<,001	0,756	1,323
Dummy_2001_2010	0,182	0,008	22,601	<,001	0,714	1,4
Dummy_2011_2020	0,22	0,014	15,788	<,001	0,878	1,139
Kilometer_from_carfreezone	-0,066	0,002	-29,96	<,001	0,615	1,627

a. Dependent Variable: Log_Transactionprice_neighborhood_median